Appendix RD – Procedures for Determining Refrigerant Charge for Split System Space Cooling Systems without a charge indicator light

John Proctor 6/16/06 4:06 PM
Deleted: without Thermostatic Expansion Valves

RD.1 Purpose and Scope

The purpose of this procedure is to determine and verify that residential split system space cooling systems and heat pumps have the required refrigerant charge and that the metering device is working as designed. The procedures only apply to ducted split system central air conditioners and ducted split system central heat pumps. The procedures do not apply to packaged systems. For dwelling units with multiple split systems or heat pumps, the procedure shall be applied to each system separately. The procedures detailed in ACM Appendix RD-2008 are intended to be used after the HVAC installer has installed and charged the air conditioner or heat pump system in accordance with the manufacturer's instructions and specifications for the specific model equipment installed. The installer shall certify to the builder, building official and HERS rater that he/she has followed the manufacturer's instructions and specifications prior to proceeding with the procedures in this appendix.

John Proctor 6/16/06 4:07 PM
Deleted: that do not have thermostatic expansion valves (TXVs)

John Proctor 7/11/06 7:58 AM
Deleted: separately.
The

Appendix RD-2008 defines two procedures, the Standard Charge Measurement Procedure in Section RD2 and the Alternate Charge Measurement Procedure in Section RD3. The Standard procedure shall be used when the outdoor air temperature is 55°F or above and shall always be used for HERS rater verification. HVAC installers who must complete system installation when the outdoor temperature is below 55°F shall use the Alternate procedure.

John Proctor 6/16/06 4:07 PM
Deleted: 2005

The following sections document the instrumentation needed, the required instrumentation calibration, the measurement procedure, and the calculations required for each procedure. Note: Wherever thermocouples appear in this document, thermisters can be used instead with the same requirements applying to thermisters as to thermocouples.

John Proctor 6/16/06 4:07 PM
Deleted: 2005

The reference method algorithms adjust (improve) the efficiency of split system air conditioners and heat pumps when they are diagnostically tested to have the correct refrigerant charge and the metering device is operating properly. Table RD-1 summarizes the algorithms that are affected by refrigerant charge testing.

John Proctor 6/16/06 4:08 PM
Deleted: or when field verification indicates that a TXV has been installed

John Proctor 6/16/06 4:09 PM
Deleted: or field verification of a TXV

Table RD-1 – Summary of Diagnostic Measurements

				Proposed Design	
Input to the Algorithms	Variables and Equation Reference	Description	Standard Design Value	Default Value	Procedure
Cooling System Refrigerant Charge and Metering	Fchg (Eq. R4-40 and R4-41)	Fchg takes on a value of 0.96 when the system has been diagnostically tested for the correct refrigerant charge. Otherwise, Fchg has a value of 0.90.	Split systems are assumed to have refrigerant charge testing when required by Package D.	No refrigerant charge testing.	RD2 or RD3

John Proctor 6/16/06 4:18 PM
Deleted: FTXV

John Proctor 6/16/06 4:18 PM
Deleted: FTXV

John Proctor 6/16/06 4:18 PM
Deleted: or TXV

John Proctor 6/16/06 4:18 PM
Deleted: or a TXV

John Proctor 6/16/06 4:18 PM
Deleted: FTXV

Note that diagnostically testing the refrigerant charge requires a minimum level of airflow across the evaporator coil.

John Proctor 6/16/06 4:20 PM
Deleted: a prerequisite for d

RD.2 Standard Charge Measurement Procedure

This section specifies the Standard charge measurement procedure. Under this procedure, required refrigerant charge is calculated using the *Superheat Charging Method for Fixed Metering Devices and the Subcooling Charging Method for TXVs and EXVs*. The method also checks airflow across the evaporator coil to determine whether the charge test is valid using the *Temperature Split Method*. The measurement methods in ACM RE-2008 may be substituted for the *Temperature Split Method* , however the *Temperature Split Method* may not be substituted for the measurement methods in ACM RE-2008.

John Proctor 6/16/06 4:20 PM
Deleted: is to verify that there is adequate airflow over the evaporator coil. This diagnostic test is described in ACM RE-2005.

The Standard procedure detailed in this section shall be completed when the outdoor temperature is 55°F or higher after the HVAC installer has installed and charged the system in accordance with the manufacturer's specifications. If the outdoor temperature is between 55°F and 65°F the return dry bulb temperature shall be maintained above 70°F during the test. All HERS rater verifications are required to use this Standard procedure.

John Proctor 6/16/06 4:23 PM
Deleted: or the air flow

John Proctor 6/16/06 4:25 PM
Deleted: 2005

John Proctor 6/16/06 4:24 PM
Deleted: .

RD.2.1 Minimum Qualifications for this Procedure

Persons carrying out this procedure shall be qualified to perform the following:

- Obtain accurate pressure/temperature readings from refrigeration manifold gauges.
- Obtain accurate temperature readings from thermometer and thermocouple set up.
- Check calibration of refrigerant gauges using a known reference pressure and thermometer/thermocouple set up using a known reference temperature.
- Determine best location for temperature measurements in ducting system and on refrigerant line set.
- Calculate the measured superheat and temperature split.
- Determine the correct level of superheat and temperature split required, based on the conditions present at the time of the test.
- Determine if measured values are reasonable.

RD.2.2 Instrumentation Specifications

Instrumentation for the procedures described in this section shall conform to the following specifications:

RD.2.2.1 Digital Thermometer

Digital thermometer shall have thermocouple compatibility (type K and J) and Celsius or Fahrenheit readout with:

- Accuracy: ±(0.1% of reading + 1.3º F).
- Resolution: 0.2º F.

RD.2.2.2 Thermocouples

Measurements require five (5) heavy duty beaded low-mass wire thermocouples and one (1) cotton wick for measuring wet-bulb temperatures.

RD.2.2.3 Refrigerant Manifold Gauge Set

A standard multiport refrigerant manifold gauge with an accuracy of plus or minus 3% shall be used.

RD.2.3 Calibration

The accuracy of instrumentation shall be maintained using the following procedures. A sticker with the calibration check date shall be affixed to each instrument calibrated.

RD2.3.1 Thermometer/Thermocouple Field Calibration Procedure

Thermometers/thermocouples shall be calibrated monthly to ensure that they are reading accurate temperatures.

The following procedure shall be used to check thermometer/thermocouple calibration:

1. Fill an insulated cup (foam) with crushed ice. The ice shall completely fill the cup. Add water to fill the cup.
2. Insert two thermocouples into the center of the ice bath and attach them to the digital thermometer.
3. Let the temperatures stabilize. The temperatures shall be 32°F (+/- 1°F). If the temperature is off by more than 1°F make corrections according to the manufacturer's instructions. Any thermocouples that are off by more than 3°F shall be replaced.
4. Switch the thermocouples and ensure that the temperatures read on T1 and T2 are still within +/- 1°F of 32°F.
5. Affix sticker with calibration check date onto thermocouple.
6. Repeat the process for all thermocouples.

RD.2.3.2 Refrigerant Gauge Field Check Procedure

Refrigerant gauges shall be checked monthly to ensure that the gauges are reading the correct pressures and corresponding temperatures. The following procedure shall be used to check gauge calibration:

1. Place a refrigerant cylinder in a stable environment and let it sit for 4 hours minimum to stabilize to the ambient conditions.

2. Attach a thermocouple to the refrigerant cylinder using duct tape so that there is good contact between the cylinder and the thermocouple.

3. Insulate the thermocouple connection to the cylinder (closed cell pipe insulation can be taped over the end of the thermocouple to provide the insulation).

4. Zero the low side compound gauge with all ports open to atmospheric pressure (no hoses attached).

5. Re-install the hose and attach the low side gauge to the refrigerant cylinder.

6. Read the temperature of the thermocouple.

7. Using a pressure/temperature chart for the refrigerant, look up the pressure that corresponds to the temperature measured.

8. If gauge does not read the correct pressure corresponding to the temperature, the gauge is out of calibration

and needs to be replaced or returned to the manufacturer for calibration.

9. Repeat the process in steps 4 through 8 for the high side gauge.

10. Affix sticker with calibration check date onto refrigerant gauge.

RD.2.4 Charge Measurement

The following procedure shall be used to obtain measurements necessary to adjust required refrigerant charge as described in the following sections:

1. If the condenser air entering temperature is less than 65ºF, establish a return air dry bulb temperature sufficiently high that the return air dry bulb temperature will be not less than 70ºF prior to the measurements at the end of the 15 minute period in step 2.

2. Turn the cooling system on and let it run for 15 minutes to stabilize temperatures and pressures before taking any measurements. While the system is stabilizing, proceed with setting up the temperature measurements.

3. Connect the refrigerant gauge manifold to the suction line service valve.

4. Attach a thermocouple to the suction line near the suction line service valve. Be sure the sensor is in direct contact with the line and is well insulated from air temperature.

5. Attach a thermocouple to the liquid line near the liquid line service valve. Be sure the sensor is in direct contact with the line and is well insulated from air temperature.

(Clamp on thermocouples are recommended for refrigerant line temperatures)

6. Attach a thermocouple to measure the condenser (entering) air dry-bulb temperature. The sensor shall be placed so that it records the average condenser air entering temperature and is shaded from direct sun.

7. Be sure that all cabinet panels that affect airflow are in place before making measurements. The thermocouple sensors shall remain attached to the system until the final charge is determined.

8. Place wet-bulb thermocouple in water to ensure it is saturated when needed. **Do not get the dry-bulb thermocouples wet.**

9. Insert the dry-bulb thermocouple in the supply plenum at the center of the airflow.

10. At 12 minutes, insert a dry-bulb thermocouple and a wet-bulb thermocouple into the return plenum at the center of the airflow.

11. At 15 minutes when the return plenum temperatures have stabilized, using the thermocouples already in place, measure and record the return (evaporator entering) air dry-bulb temperature ($T_{return, db}$) and the return (evaporator entering) air wet-bulb temperature ($T_{return, wb}$).

12. Using the dry-bulb thermocouple already in place, measure and record the supply (evaporator leaving) air drybulb temperature ($T_{supply, db}$).

13. Using the refrigerant gauge already attached, measure and record the evaporator saturation temperature ($T_{evaporator, sat}$) from the low side gauge.

John Proctor 6/16/06 4:31 PM
Deleted: 5

John Proctor 6/16/06 4:31 PM
Deleted: 6

John Proctor 6/16/06 4:32 PM
Deleted: 7

John Proctor 6/16/06 4:32 PM
Deleted: 8

John Proctor 6/16/06 4:32 PM
Deleted: 9

John Proctor 6/16/06 4:32 PM
Deleted: 10

John Proctor 6/16/06 4:32 PM
Deleted: 11

John Proctor 6/16/06 4:32 PM
Deleted: 12

14. Using the refrigerant gauge already attached, measure and record the condenser saturation temperature ($T_{condenser, sat}$) from the high side gauge.

15. Using the thermocouple already in place, measure and record the suction line temperature ($T_{suction}$).

16. Using the thermocouple already in place, measure and record the liquid line temperature (T_{liquid}).

17. Using the dry-bulb thermocouple already in place, measure and record the condenser (entering) air dry-bulb temperature ($T_{condenser, db}$).

The above measurements shall be used to adjust refrigerant charge and airflow as described in following sections.

RD.2.5 Refrigerant Charge and Metering Device Calculations

The following steps describe the calculations to determine if the system meets the required refrigerant charge and metering device function using the measurements described in Section RD2.4. If a system fails, then remedial actions must be taken. If the refrigerant charge is changed and the airflow is being tested with the *Temperature Split Method*., then the airflow shall be re-tested. Be sure to complete Steps 1 and 2 of Section RD2.4 before re-testing the airflow. Both the airflow and charge must be re-tested until they both sequentially pass.

RD.2.5.1 Fixed Metering Device Calculations

The Superheat Charging Method is used only for systems equipped with fixed metering devices. These include capillary tubes and piston-type metering devices.

1. Calculate Actual Superheat as the suction line temperature minus the evaporator saturation temperature. Actual Superheat = $T_{suction}$ – $T_{evaporator, sat}$.

2. Determine the Target Superheat using Table RD2 using the return air wet-bulb temperature ($T_{return, wb}$) and condenser air dry-bulb temperature ($T_{condenser, db}$).

3. If a dash mark is read from Table RD-2, the target superheat is less than 5°F, then the system **does not pass** the required refrigerant charge criteria, usually because outdoor conditions are too hot and dry. One of the following adjustments is needed until a target superheat value can be obtained from Table RD-2 by either 1) turning on the space heating system and/or opening the windows to warm up indoor temperature; or 2) retest at another time when conditions are different. After adjustments, repeat the measurement procedure as often as necessary to establish the target superheat. Allow system to stabilize for 15 minutes before completing the measurement procedure again.

4. Calculate the difference between actual superheat and target superheat (Actual Superheat - Target Superheat)

5. In order to allow for inevitable differences in measurements, the Pass/Fail criteria are different for the Installer and the HERS Rater.

A) For the Installer, If the difference is between minus 5 and plus 5°F, then the system **passes** the required refrigerant charge criterion.

B) For the HERS Rater inspecting the system, if the difference is between minus 6 and plus 6°F, then the system **passes** the required refrigerant charge criterion

6. For the Installer, If the difference is greater than plus 5°F, then the system **does not pass** the required refrigerant charge criterion and the Installer shall add refrigerant. After the final adjustment has been made, allow the system to run 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement procedure as many times as necessary to pass the test.

7. For the Installer, If the difference is between minus 5 and minus 100°F, then the system **does not pass** the required refrigerant charge criterion, the Installer shall remove refrigerant. After the final adjustment has been made, allow the system to run 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement procedure as many times as necessary to pass the test.

RD.2.5.2 Variable Metering Device Calculations

The Subcooling Charging Method is used only for systems equipped with variable metering devices. These include Thermostatic Expansion Valves (TXV) and Electronic Expansion Valves (EXV) metering devices. Since variable metering devices are constant superheat valves, measuring the superheat determines whether they are working properly.

John Proctor 6/16/06 4:34 PM
Deleted: 13

John Proctor 6/16/06 4:34 PM
Deleted: dry-bulb

John Proctor 6/16/06 4:35 PM
Deleted: db

John Proctor 6/16/06 4:35 PM
Deleted: 14

John Proctor 6/16/06 5:04 PM
Deleted: The Superheat Charging Method is used only for non-TXV systems equipped with fixed metering devices. These include capillary tubes and piston-type metering devices.

John Proctor 6/16/06 5:36 PM
Deleted: and the airflow has been previously tested and shown to pass

John Proctor 6/16/06 5:04 PM
Deleted: db

John Proctor 6/16/06 5:08 PM
Deleted: a

John Proctor 6/16/06 5:12 PM
Deleted: criteria

John Proctor 6/16/06 5:15 PM
Deleted: installer

John Proctor 6/16/06 5:13 PM
Deleted: refrigerant has been added, turn the system on and

John Proctor 6/16/06 5:13 PM
Deleted: it

John Proctor 6/16/06 5:13 PM
Deleted: to stabilize for

John Proctor 6/16/06 5:38 PM
Deleted: –

John Proctor 6/16/06 5:38 PM
Deleted: -

John Proctor 6/16/06 5:16 PM
Deleted: a

John Proctor 6/16/06 5:16 PM
Deleted: installer

John Proctor 6/16/06 5:17 PM
Deleted: After the refrigerant has been removed, turn the system on and allow it to stabilize for 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement as many times as necessary to pass the test

1. Calculate Actual Subcooling as the liquid line temperature minus the condenser saturation temperature. Actual Subcooling = $T_{liquid,} - T_{condenser, sat.}$

2. Determine the Target Subcooling specified by the manufacturer.

4. Calculate the difference between actual subcooling and target subcooling (Actual Subcooling - Target Subcooling

5. In order to allow for inevitable differences in measurements, the Pass/Fail criteria are different for the Installer and the HERS Rater.

A) For the Installer, If the difference is between minus 3°F and plus 3°F, then the system **passes** the required refrigerant charge criterion.

B) For the HERS Rater inspecting the system, if the difference is between minus 4°F and plus 4°F, then the system **passes** the required refrigerant charge criterion

6. For the Installer, If the difference is greater than plus 3°F, then the system **does not pass** the required refrigerant charge criterion and the Installer shall remove refrigerant. After the final adjustment has been made, allow the system to run 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement procedure as many times as necessary to pass the test.

7. For the Installer, If the difference is between minus3°F and minus 100°F, then the system **does not pass** the required refrigerant charge criterion, the Installer shall add refrigerant. After the final adjustment has been made, allow the system to run 15 minutes before completing the measurement procedure again. Adjust refrigerant charge and repeat the measurement procedure as many times as necessary to pass the test..

8. Calculate Actual Superheat as the suction line temperature minus the evaporator saturation temperature. Actual Superheat = $T_{suction,} - T_{evaporator, sat.}$

9. If possible, determine the Superheat Range specified by the manufacturer.

10. In order to allow for inevitable differences in measurements, the Pass/Fail criteria are different for the Installer and the HERS Rater.

A) For the Installer, If the superheat, is within the manufacturer's superheat range, then the system **passes** the metering device criterion. If the manufacturer's specification is not available and the superheat is between 4°F and 25°F, then the system **passes** the metering device criterion.

B) For the HERS Rater inspecting the system, if the superheat is between 3°F and 26°F, then the system **passes** the metering device criterion.

RD.2.6 Minimum Airflow

In order to have a valid charge test, the air flow shall be verified by either passing the temperature split test. Alternatively, one of the three measurements in ACM Appendix RE-2008 may be used with a measured airflow in excess of 0.029 cfm/Btu capacity rated at DOE A test conditions (350 cfm/12000 Btu). The temperature split test method is designed to provide an efficient check to see if airflow is above the required minimum for a valid refrigerant charge test. The following steps describe the calculations using the measurement procedure described in Section RD2.4. If a system fails, then remedial actions must be taken. If the airflow is changed and the refrigerant charge has previously been tested, then the refrigerant charge shall be re-tested. Be sure to complete Steps 1 and 2 of Section RD2.4 before re-testing the refrigerant charge. Both the airflow and charge must be re-tested until they both sequentially pass.

1. Calculate the Actual Temperature Split as the return air dry-bulb temperature minus the supply air dry-bulb temperature. Actual Temperature Split = $T_{return, db} - T_{supply, db}$

2. Determine the Target Temperature Split from Table RD-3 using the return air wet-bulb temperature ($T_{return, wb}$) and return air dry-bulb temperature ($T_{return, db}$).

3. If a dash mark is read from Table RD-3, then there probably was an error in the measurements because the conditions in this part of the table would be extremely unusual. If this happens, re-measure the temperatures. If re-measurement results in a dash mark, complete one of the alternate airflow measurements in Section RE4.1.

4. Calculate the difference between target and actual temperature split (Actual Temperature Split-Target Temperature Split).

John Proctor 6/16/06 5:26 PM
Deleted:

John Proctor 6/16/06 5:46 PM
Deleted: Verification

John Proctor 6/16/06 5:46 PM
Deleted: or by

John Proctor 6/16/06 5:47 PM
Deleted: 2005

John Proctor 6/16/06 5:48 PM
Deleted: 033

John Proctor 6/16/06 5:47 PM
Deleted: 400

John Proctor 6/16/06 5:48 PM
Deleted: (dry coil)

John Proctor 6/16/06 5:48 PM
Deleted: and shown to pass

5. In order to allow for inevitable differences in measurements, the Pass/Fail criteria are different for the Installer and the HERS Rater.

A) For the Installer,

if the difference, is between plus 3°F and minus 3°F, then the system **passes** the adequate airflow criterion.

If the difference is greater than plus 3°F, then the system **does not pass** the adequate airflow criteria and the airflow shall be increased by the installer. Increasing airflow can be accomplished by eliminating restrictions in the duct system, increasing blower speed, cleaning filters, or opening registers. After corrective measures are taken, repeat measurement procedure as often as necessary to establish adequate airflow range. Allow system to stabilize for 15 minutes before repeating measurement procedure.

If the difference is between minus 3°F and minus 100°F, then the measurement procedure shall be repeated making sure that temperatures are measured at the center of the airflow

If the re-measured difference is between plus 3°F and minus 3°F the system **passes** the adequate airflow criteria. If the re-measured difference is between minus 3°F and minus 100°F, the system passes, but it is likely that the capacity is low on this system (it is possible, but unlikely, that airflow is higher than average).

B) For the HERS Rater inspecting the system,

if the difference is between plus 4°F and minus 4°F, then the system **passes** the adequate airflow criterion.

If the difference is between minus 4°F and minus 100°F, then the measurement procedure shall be repeated making sure that temperatures are measured at the center of the airflow.

If the re-measured difference is between plus 4°F and minus 4°F the system **passes** the adequate airflow criteria. If the re-measured difference is between minus 4°F and minus 100°F, the system passes, but it is likely that the capacity is low on this system (it is possible, but unlikely, that airflow is higher than average).

RD.3 Alternate Charge Measurement Procedure

This section specifies the Alternate charge measurement procedure. Under this procedure, the required refrigerant charge is calculated using the *Weigh-In Charging Method*.

HVAC installers who must complete system installation verification when the outdoor temperature is below 55°F shall use this Alternate procedure in conjunction with installing and charging the system in accordance with the manufacturer's specifications. HERS Raters shall not use this procedure to verify compliance. Split system air conditioners come from the factory already charged with the standard charge indicated on the name plate. The manufacturer supplies the charge proper for the application based on their standard liquid line length. It is the responsibility of the HVAC installer to ensure that the charge is correct for each air conditioner and to adjust the charge based on liquid line length different from the manufacturer's standard.

John Proctor 6/26/06 9:05 AM
Deleted: If the difference is within plus 3°F and minus 3°F, then the system **passes** the adequate airflow criteria.

John Proctor 6/26/06 9:09 AM
Deleted: 5. If the difference is greater than plus 3°F, then the system **does not pass** the adequate airflow criteria and the airflow shall be increased by the installer. Increasing airflow can be accomplished by eliminating restrictions in the duct system, increasing blower speed, cleaning filters, or opening registers. After corrective measures are taken, repeat measurement procedure as often as necessary to establish adequate airflow range. Allow system to stabilize for 15 minutes before repeating measurement procedure.
6.

John Proctor 6/26/06 9:11 AM
Deleted: 3

John Proctor 6/26/06 9:12 AM
Deleted: 7.

John Proctor 6/26/06 9:11 AM
Deleted: 3

John Proctor 6/26/06 9:11 AM
Deleted: 3

John Proctor 6/26/06 9:11 AM
Deleted: 3